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WAVEGUIDE FILTERS ON THE LUMPED ELEMENTS

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In mobile microwaves systems traditional waveguide filters appear to be too big. A way out is the application of structures on the lumped elements. The ways of realization of this idea are below described.

Filters with quarter wave couplings. The improvement of selective properties can be received when replacing a parallel resonant circuit by a pair of rejection circuits (fig. 1*a*).
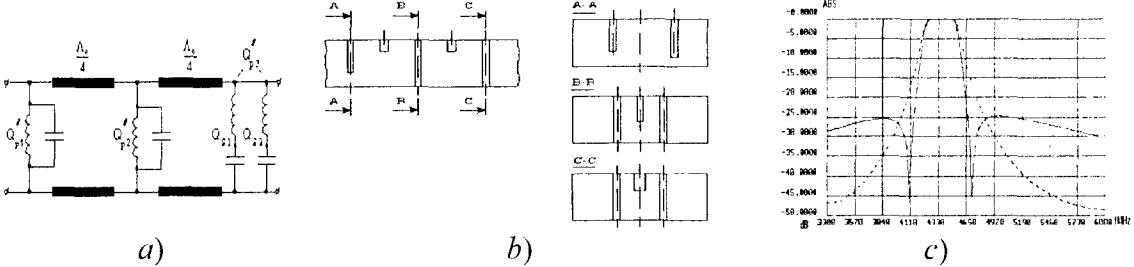

Fig. 1. Three-section filter with quarter wave couplings when replacing one resonant circuit by a pair of rejection circuits: *a*) circuit, *b*) a design, *c*) frecuency responce

At the allocation of two resonators on the distance less than 90^0 the characteristic turns out to be double-humped (fig. 2*b*). At the replacement of one passing circuit by a pair of rejection circuits the characteristics on Cauer type are received.
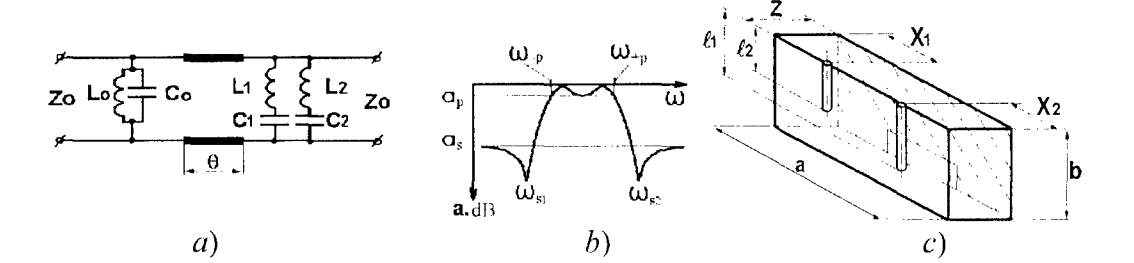

Fig. 2. A passing cascade section at the replacement of one passing circuit by a pair of rejection circuits (*a*), its frequency response (*b*) and design (*c*)
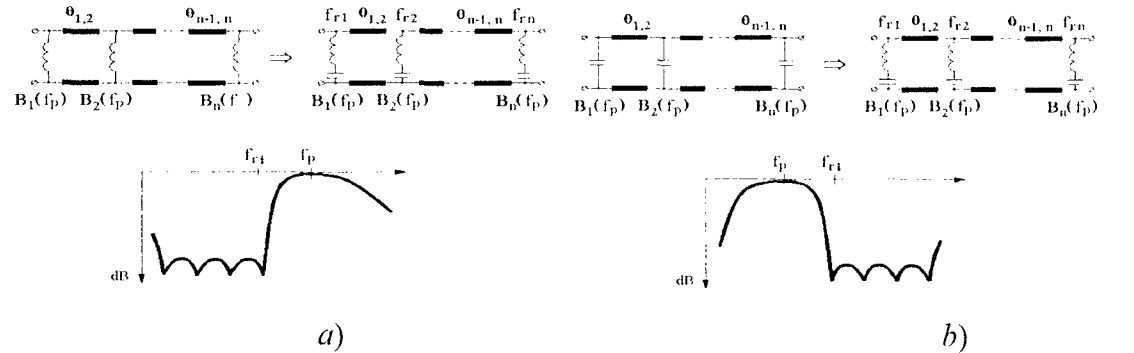

Fig. 3. Transformation of a polynomial filter into the filter with poles: *a*) in the bottom stopband (quasi- high-pass filter); *b*) in the top stopband (quasi-low-pass filter)

Practically such a filter is carried out as a short waveguide insertion (fig.2c). The original filter – a flange with the electric length 60–70° ($\approx \Lambda/5 - \Lambda/6$) is received. Its characteristic is shown on fig.2b.

Passband filters with direct couplings. If in the filter with direct couplings the jet irregularity is replaced with a rejection circuit we shall receive the filter with the asymmetrical characteristics (fig.3). The method of synthesis of such filters - prototypes is developed. On fig. 4 the design of a similar filter and its frequency characteristics is shown.
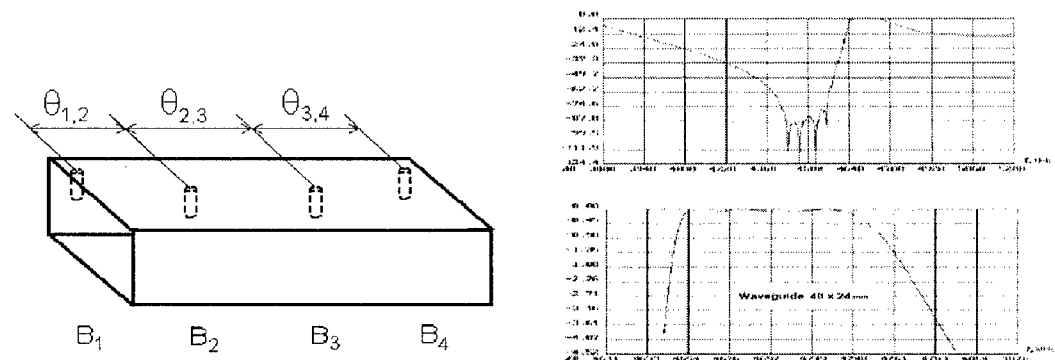

Fig. 4. The design of three-section filter
and. frequency characteristics of a quasi- high-pass filter

Waveguide filters with a ladder structure. It is experimentally proved, that in waveguides it is possible to realize a ladder circuit without introduction of inverters of immitances. Two circuits of a five-section filter (fig.5) have been examined.
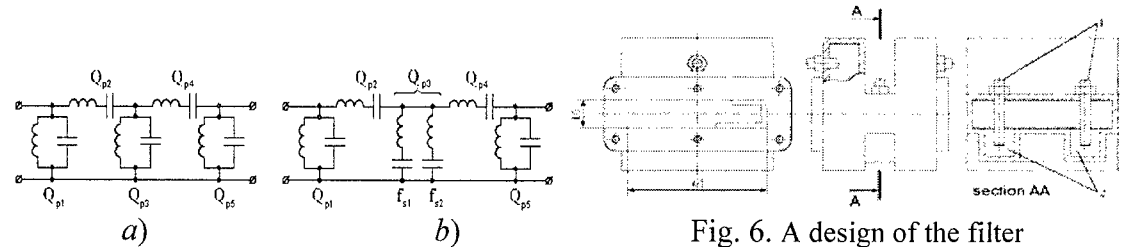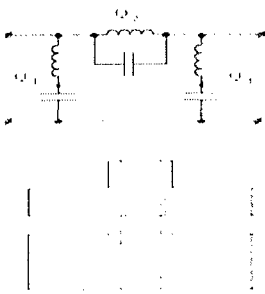

a)   b)   Fig. 6. A design of the filter
Fig. 5. Ladder circuits of five-section filters   under the circuit fig.5b

The filter design according to the scheme of fig. 5b, is shown on fig. 6. Here quality Q_3 is formed by a pair of rejection circuits. On fig.6 these rejection circuits are executed as resonant posts 1. Parallel circuits realized as a resonant diaphragm with the U-shaped aperture. Q-factor is determined by the size of shift of the ends of a slot. The length of a slot is made a little bit shorter than that of the resonant one. The tuning screw, located near a longer horizontal part of a slot, is shifted along a waveguide with regard to a plane of a diaphragm. Series circuits represent two short-circuited stubs included into the opposite wide walls. The filter is executed from two identical units between the flanges of which central diaphragm Q_{p3} is inserted. Two filters executed according to the schemes of fig. 5a and 5b have been experimentally investigated. In a passband the loss of both filters does not exceed 0.2 dB. The length of filters: according to the

scheme of fig. 5*a* - 48 mm, according to the scheme of fig. 5*b*– 44 mm, that is a bit less than half of a wave length in a waveguide.

Rejection filters with direct coupling. At low requirements to a slope steepness it is possible to build a stopband filter on circuits with direct coupling (fig. 7). Resonant posts are placed in reference planes T of the E-plane junction. As the experience shows, at such connection the equivalent qualities of a stub and especially posts are reduced due to the additional coupling. To reduce this coupling it is possible to use diaphragms or – which is easier structurally - to carry out a stub on a waveguide of a smaller section.

Fig. 7.Rejection filters with direct couplings

Filters with a low-pass filter structure. Capacitor elements are carried out as flat capacitor diaphragms. The opportunity to reduce sizes of series inductances follows from the expression for wave resistance of a waveguide: $Z_{\mu} = bA / a\sqrt{1 - (\lambda/2a)^2}$, where A – is a constant dependent on a method of wave resistance definition .
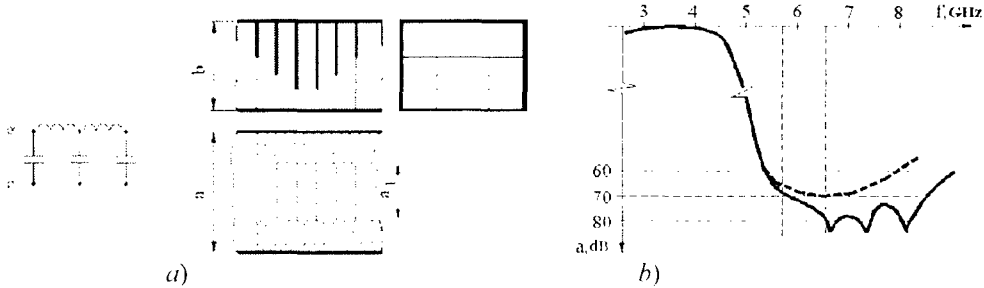

Fig. 8. The low-pass filter on capacitor diaphragms

Hence it is clear, that for the wave resistance increase the height b is increased or the wide wall a is narrowed. It allows to make the inductive elements length much smaller than the wave length i.e. to receive practically lumped elements. This idea is used when creating LPF (fig. 8) and the transformer for connection of 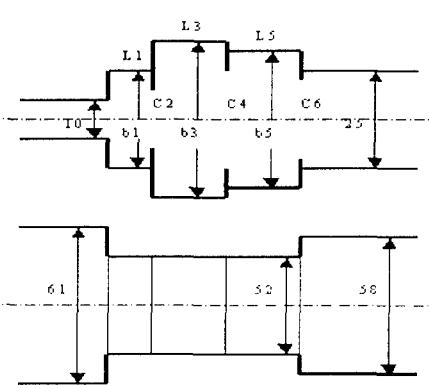waveguides with different height. In the latter case the filter from [1] was a low-frequency prototype. The transformer connects waveguides with the section 58x25 and 61x10 mm. The quarter wave transformer similar in parameters contains three links and has length $3\lambda/4$. Thus, the trans- former considered gives a gain in a length approximately 4.5 times. In the band of frequencies 3.2–4.2 GHz VSWR did not exceed the value 1.16. The transformer has 6 reactive elements. Structurally it represents a package of linings in which windows of different section (fig.9) are cut out. The full length of the transformer is 20 mm.

Fig.9. The design of transformer

REFERENCE

[1] Matthaei G.L. Tables of Chebyshev impedance transforming networks of low-pass filter form. – Proc. IEEE, 1964, v.52, №8, pp.939-963